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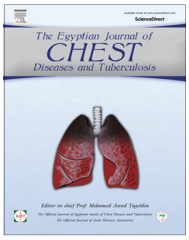

ORIGINAL ARTICLE

Ultrasound guided closed pleural biopsy versus medical thoracoscopic pleural biopsy in diagnosis of pleural diseases

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KEYWORDS

Pleural diseases;
Transthoracic ultrasound;
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Abstract *Background:* The diagnostic approach to pleural disease remains an underappreciated aspect of modern thoracic medicine, despite the fact that pleural disease affects approximately 300 subjects per 100,000 population per year worldwide. Tissue biopsies required for diagnosis can be obtained by various methods; blind pleural biopsy, guided biopsy, medical thoracoscopic or surgical pleural biopsy.

Aim of the work: To compare the diagnostic efficiency, reliability, complications and advantages of transthoracic ultrasound guided (TUS) pleural biopsies with those of medical thoracoscopic pleural biopsies in patients with pleural diseases.

Patients and methods: This study included 71 patients with pleural disease. All patients were subjected to complete history taking, full clinical examination, CT chest, TUS examination with TUS guided biopsies for legible cases and medical thoracoscopic biopsies for legible cases. The patients included in the study were classified according to the procedure by which pleural biopsy was divided into 3 groups: Group 1 (39 patients underwent medical thoracoscopic pleural biopsies alone), Group 2 (10 patients underwent TUS pleural biopsies alone), Group 3 (22 patients underwent pleural biopsies by both techniques). The patients included in the study were classified according to the pathology of the lesions into Group A (51 patients with malignant lesions) and Group B (included 20 patients with non-malignant lesions). The malignant patients included in the study were classified according to the pathology of the lesions into Group A1 (24 patients with primary malignant lesions) and Group A2 (27 patients cases with secondary malignant lesions).

Results: TUS guided pleural biopsies had a sensitivity of 77.78% and diagnostic accuracy of 81.25%; while medical thoracoscopic pleural biopsies had a sensitivity of 94% and a diagnostic accuracy of 95.08%.

Conclusion: Both TUS guided pleural biopsy and medical thoracoscopic pleural biopsy are available to diagnose different pleural lesions each of which has its advantages and disadvantages. The proper selection of the patients for each modality will result in raising the diagnostic yield of both modalities. TUS examination before medical thoracoscopy will allow proper selection of

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patients, reduce incidence of complications, guide for the best site of entry and raisethe diagnostic yield of medical thoracoscopy.

Introduction

The diagnostic approach to pleural disease remains an underappreciated aspect of modern thoracic medicine, despite the fact that pleural disease affects approximately 300 subjects per 100,000 population per year worldwide [1]. Yet, the most efficient and cost-effective approach to pleural diseases remains uncertain and even controversial, particularly if acquisition of pleural tissue is required.

Medical thoracoscopy allows for the direct inspection of the pleura and biopsies taken under direct vision, has a diagnostic yield superior to that of blind closed pleural biopsy and thoracocentesis. The diagnostic yield is in the order of 91–95% for malignant disease and can be as high as 100% for pleural TB [2]. Medical thoracoscopy remains an invasive procedure, but complications are infrequently seen. Hemorrhage, secondary empyema and other major complications are only seen in 2–3% of cases, and death is exceedingly rare (0.4%). In fact, 2010 British Thoracic Society (BTS) pleural disease guidelines state that thoracoscopy is the investigation of choice in exudative pleural effusion where a diagnostic pleural aspiration is inconclusive and malignancy is suspected [3].

Recent studies have proposed that image guided pleural biopsies may significantly increase the diagnostic yield over blind pleural biopsies while decreasing the risk of complications. Transthoracic ultrasound (TUS) is an ideal aid to the clinician, given its mobility, lack of irradiation and short examination time. TUS can locate the best pleural access point and also detect thick fibrous septation; it improves the accuracy of pleural puncture sites by 26% [4]. TUS also allows access in 88% of patients after unsuccessful clinically guided thoracocentesis and reduces complications [5]. Moreover, the volume of fluid, the presence of septation, pleural thickening, nodules and pleural based tumours can be accurately assessed [4]. These simple yet practical considerations need to be emphasized when comparisons are made with thoracoscopy.

This study aimed to compare the diagnostic efficiency, reliability, complications and advantages of TUS pleural biopsies with medical thoracoscopic pleural biopsies in patients with pleural diseases.

Subjects

The present study included 71 patients who were selected from the Chest Department inpatients, Kasr Alainy Hospital, in the period from February 2013 to July 2014. The selected patients had either exudative pleural effusion according to the light's criteria [6] pleural thickening, pleural nodules or pleural masses that allow pleural biopsy to be performed. Patients with transudative pleural effusion, bleeding disorders, extensive adhesions with no sufficient space to perform medical thoracoscopy or unfit for pleural biopsy procedures were excluded from undergoing medical thoracoscopy. Patients with bleeding disorders or inaccessible pleural lesion for real time US guided biopsy were excluded from undergoing closed pleural biopsy.

The included patients were divided into 3 subgroups according to procedure by which pleural biopsy is obtained:

- *Group I:* included 39 patients who underwent medical thoracoscopic pleural biopsies alone (as lesions were inaccessible for TUS real time biopsies; e.g., behind rib).
- *Group II:* included 10 patients who underwent TUS pleural biopsies alone (due to diffuse pleural thickening or extensive thick adhesions with no space for medical thoracoscopy).
- *Group III:* included 22 patients who underwent pleural biopsies by both techniques.

The included patients were divided into 2 subgroups according to the pathology of the lesions:

- *Group A:* included 51 patients with malignant lesions.
- *Group B:* included 20 patients with non- malignant lesions.

The malignant patients included in the study were divided into 2 subgroups according to the pathology of the lesions:

- *Group A1:* included 24 patients with primary malignant lesions.
- *Group A2:* included 27 patients with secondary malignant lesions.

Methods

All included patients were subjected to:

- Written informed consent.
- Full history taking.
- Detailed clinical examination.
- Bleeding profile.
- CT scan of the chest which was used to detect the following:
  (a) The presence of pleural nodules (lesions < 3 cm in largest diameter) or pleural masses (lesions > 3 cm in largest diameter).
  (b) Pleural fibrosis and pleural effusion (free or loculated).
  (c) The character of the collapsed lung either *bulky collapse* (lung that didn't collapse totally under the effusion with no aeration and preserved some volume) or *healthy collapse* (lung that collapsed totally under the effusion).
- Biochemical, pathological and microbiological evaluation of the pleural aspirates for cases with pleural effusion.
- Transthoracic ultrasonographic study with ultrasound guided pleural biopsy in legible cases: (using Hitachi 7000). All cases were examined with curvilinear transducer (3.5 MHz) and linear array transducer (7.5 MHz).

Screening of the patient's chest using the low frequency probe. Detection of pleural effusion, pleural thickness, pleural nodules (lesions <3 cm in largest diameter) or pleural masses (lesions >3 cm in largest diameter). Detection of the character of the collapsed lung either *bulky collapse* (lung that didn't collapsed totally under the effusion with no aeration and preserved some volume) or *healthy collapse* (lung that collapse totally under the effusion).

Also the size of the effusion was documented as follows: *Mild* (if the space was greater than the costophrenic angle but still within the range of the area covered with a 3.5 MHz curvilinear probe), *moderate* (if the space was greater than one probe range but within a two probe range and *Massive* (if the space was larger than a two-probe range).

For US guided biopsies, the biopsy site was identified and all biopsies were performed using semi-automatic Tru cut needle under direct TUS guidance, while in cases who underwent Abrams pleural biopsy the best site for biopsy was marked by TUS and biopsy was taken blindly. At least three Tru-cut needle biopsies were taken using a 14 gauge cutting needle then all the biopsies were sent for histopathological examination [7].

- Medical thoracoscopic pleural biopsy was done in legible cases using KARL-STORZ rigid thoracoscopy with a cold light source. The single-entry technique for medical thoracoscopy was used in all cases. The puncture site is usually in the mid- axillary zone between the 4th and 6th intercostal spaces. Choice of the point of entry varied depending on the site of dullness, guided by CT chest [8] and TUS examination pre-medical thoracoscopy to detect the best site of entry.

Good inspection of the lung surface and pleural cavity was done to detect the presence of pleural nodules (lesions <3 cm in largest diameter) or pleural masses (lesions >3 cm in largest diameter), compared to the length of open forceps' jaw which was found to be 1 cm. Also the character of the collapsed Lung, after aspiration of pleural effusion, by gentle pushing of closed forceps was assessed and classified into: (i) *bulky lung* with doughy sensation on pushing by closed forceps; (ii) *healthy collapsed lung* with spongy sensation.

Multiple biopsies were taken under direct vision from suspicious sites on parietal (especially posterior costodiaphragmatic recess) or diaphragmatic pleurae. Sometimes lung (recommended sonographically), biopsies were obtained using electrocautery forceps. All thoracoscopic pleural and lung biopsies were sent for histopathological examination.

Statistical analysis

Data were statistically described in terms of mean ± standard deviation (±SD), median and range, or frequencies (number of cases) and percentages when appropriate. Comparison of numerical variables between the study groups was done using Student *t* test for independent samples by comparing 2 groups when normally distributed and Mann–Whitney *U* test for independent samples when not normally distributed. Comparison of numerical variables between more than two groups in the present study was done using Kruskal–Wallis test. Within group comparison of numerical variables was done using paired *t* test by comparing 2 groups when normally distributed and Wilcoxon signed rank test for paired (matched) samples when not normally distributed. For comparing categorical data, Chi square (χ^2) test was performed. Exact test was used instead when the expected frequency is less than 5. Comparison and agreement between the different diagnostic modalities were done using McNemar and kappa tests. Accuracy was represented using the terms sensitivity, specificity, +ve predictive value, −ve predictive value, and overall accuracy. p values less than 0.05 were considered statistically significant. All statistical calculations were done using computer program SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) release 15 for Microsoft Windows (2006).

Results

The present study included 71 patients who fulfilled the selection criteria and formed the study population. The study patients were divided into 3 groups; Group I: included 39 cases who underwent medical thoracoscopic pleural biopsy alone, (they were 11 males and 28 females with a mean age of 53.69), Group II: included 10 cases who underwent TUS guided pleural biopsies (they were 8 males and 2 females with a mean age of 61.07), Group III: included 22 cases who underwent biopsies by both techniques (they were 11 males and 11 females with a mean age of 55.45).

The patients included in the study were also classified according to the final histopathological results, into two groups; *Group A:* included 51 cases with malignant lesions (they were 24 males and 27 females with mean age of 57.2) and *Group B:* included 20 cases with non-malignant lesions (they were 6 males and 14 females with a mean age of 49.479). The malignant patients included in the study (Group A) were further classified into *Group A1:* included 24 cases with primary malignant lesions (they were 13 males and 11 females with a mean age of 58.3) and *Group A2:* included 27 cases with secondary malignant lesions (they were 11 males and 16 females with an average age of 55.8).

Regarding site of lesions, CT chest revealed that 54.9% of cases had right sided lesions, 39.5% of cases had left sided lesions and 5.6% had bilateral lesions and TUS data revealed that 56.3% of cases had right sided lesions, 40.9% had left sided lesions and 2.8% of cases had bilateral lesions.

Regarding the comparison between medical thoracoscopy and either CT chest or TUS in the ability of detection of pleural masses there was no statistically significant difference (Table 1), also there was no statistically significant difference comparing them together (Table 2).

Comparing the ability to detect pleural nodules by CT chest or TUS versus medical thoracoscopy, this study revealed that there was no statistically significant difference between TUS and medical thoracoscopy ($p = 0.570$) (Table 3), while medical thoracoscopy was superior over CT chest in detection of pleural nodules with statistically significant difference ($p = 0.000$) (Table 3), while comparing the ability to detect pleural nodules by medical thoracoscopy, CT chest and TUS, this study revealed that there was statistically significant difference ($p = 0.001$) (Table 2).

Regarding the ability to detect pleural nodules by TUS (Table 4), (Fig. 1) there was statistically significant difference ($p = 0.025$) between malignant (group A) and non-malignant groups (group B) but there was no significant difference

Table 1 Comparison between either CT chest or TUS and medical thoracoscopy in detection of pleural masses among study patients who underwent medical thoracoscopy.

		Thoracoscope masses			*p* value
		No	Yes	Total	
CT Masses	No	54 (88.5%)	4 (6.6%)	58 (95.1%)	0.299
	Yes	1 (1.6%)	2 (3.3%)	3 (4.9%)	
	Total	55 (90.1%)	6 (9.9%)	61 (100%)	
TUS Masses	No	54 (88.5%)	2 (3.3%)	56 (91.8%)	0.752
	Yes	1 (1.6%)	4 (6.6%)	5 (8.2%)	
	Total	55 (90.1%)	6 (9.9%)	61 (100%)	

($p = 1.00$) between primary (group A1) and secondary malignant cases (group A2). Regarding the ability of medical thoracoscopy in detection of pleural nodules (Table 4), (Fig. 1) there was statistically significant difference ($p = 0.009$) between group A and group B but no significant difference ($p = 0.405$) between group A1 and group A2.

Also TUS detected chest wall invasion among malignant cases and confirmed its absence in non-malignant cases, with statistically significant value (p-value = 0.015) (Table 5), while CT chest couldn't detect any case with chest wall invasion.

Comparing the ability to detect the character of the collapsed lung (bulky or healthy collapse) by CT chest or TUS versus medical thoracoscopy, this study revealed that TUS was the best modality to detect bulky lung (Table 6), also comparing the ability to detect character of the collapsed lung by medical thoracoscopy, CT chest and TUS there was no statistically significant difference ($p = 0.065$) (Table 7).

This study revealed that TUS was the best modality to detect lung mass in the secondary malignant group with statistically significant difference ($p = 0.004$) (Table 8), (Fig. 1).

Comparing the ability to detect the pattern of pleural effusion (free or loculated) by CT chest or TUS versus medical thoracoscopy, this study revealed that all techniques were close to each other, with no significant difference between all of them (Tables 9 and 10).

Regarding the diagnostic yield of used modalities for diagnosis of pleural diseases in the present study it was found that the diagnostic yield of TUS was close to that of medical thoracoscopy but the difference between them didn't reach statistical significance ($p = 0.079$) (Table 11).

Regarding the complications of both TUS guided biopsy and medical thoracoscopic biopsy, TUS guided biopsies showed no complications compared to 7 (11.5%) patients who developed complications following medical thoracoscopic biopsies including 4 cases with surgical emphysema and 3 cases with wound infection and empyema.

Discussion

The diagnostic approach to pleural diseases remains an underappreciated aspect of modern thoracic medicine, despite the fact that pleural diseases affect approximately 300 subjects per 100,000 population per year worldwide [1].

Medical thoracoscopy allows for the direct inspection of the pleura and biopsies taken under direct vision, has a diagnostic yield superior to that of blind closed pleural biopsy and thoracocentesis. The diagnostic yield is in the order of 91–95% for malignant disease and can be as high as 100% for pleural TB [2].

In fact, 2010 British Thoracic Society (BTS) pleural disease guidelines state that thoracoscopy is the investigation of choice in exudative pleural effusion where a diagnostic pleural aspiration is inconclusive and malignancy is suspected [3].

Recent studies have proposed that image guided pleural biopsies using TUS may significantly increase the diagnostic yield over blind pleural biopsies while decreasing the risk of complications.

The aim of the current study was to compare the diagnostic efficiency, reliability, complications and advantages of TUS biopsies with that of medical thoracoscopic biopsies in patients with pleural diseases.

Regarding site of lesions according to data of CT chest 54.9% of cases had right sided lesions, 39.5% of cases had left sided lesions and 5.6% had bilateral lesions. TUS data revealed that 56.3% of cases had right sided lesions, 40.9% had left sided lesions and 2.8% of cases had bilateral lesions.

Table 2 Comparison between medical thoracoscopy, CT chest and TUS in detection of pleural masses & pleural nodules among study patients who underwent medical thoracoscopy.

		Medical thoracoscopy	CT chest	TUS	*p* value
Pleural masses	Yes	6 (9.9%)	3 (4.9%)	5 (8.25%)	0.581
	No	55 (90.1%)	58 (95.1%)	56 (91.8%)	
	Total	61 (100%)	61 (100%)	61 (100%)	
Pleural nodules	Yes	55 (90.2%)	7 (11.5%)	53 (86.9%)	0.001*
	No	6 (9.8%)	54 (88.5%)	8 (13.1%)	
	Total	61 (100%)	61 (100%)	61 (100%)	

* $p < 0.05$.

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Table 3 Comparison between either CT chest or TUS and medical thoracoscopy in detection of pleural nodules among patients who underwent medical thoracoscopy.

		Thoracoscope nodule			*p* value
		No	Yes	Total	
CT nodule	No	6 (9.8%)	48 (78.7%)	54 (88.5%)	0.000*
	Yes	0 (0%)	7 (11.5%)	7 (11.5%)	
	Total	6 (9.8%)	55 (90.2%)	61 (100%)	
TUS nodule	No	5 (8.1%)	3 (5%)	8 (13.1%)	0.570
	Yes	1 (1.7%)	52 (85.2%)	53 (86.9%)	
	Total	6 (9.8%)	55 (90.2%)	61 (100%)	

* $p < 0.05$.

Table 4 Study the ability of TUS & medical thoracoscopy to detect pleural nodules among the study patients.

		Malignant				Non malignant	Grand total	*p*-Value
		Primary	Secondary	Total	*p*-Value			
TUS	Yes	22 (31%)	25 (35.2%)	47 (66.2%)	1.000	14 (19.7%)	61 (85.9%)	0.025*
	No	2 (2.8%)	2 (2.8%)	4 (5.6%)		6 (8.5%)	10 (14.1%)	
	Total	24 (33.8%)	27 (38%)	51 (71.8%)		20 (28.2%)	71 (100%)	
Medical thoracoscopy	Yes	16 (26.2%)	25 (41%)	41 (67.2%)	0.405	14 (23%)	55 (90.2)	0.009*
	No	1 (1.6%)	0 (0%)	1 (1.6%)		5 (8.2%)	6 (9.8%)	
	Total	17 (27.8%)	25 (41%)	42 (68.8%)		19 (31.2%)	61 (100%)	

* $p < 0.05$.

The current study agreed with Enas et al. [9] found by CT chest that 70% of cases had right sided lesions and 30% had left side lesions.

Regarding the comparison between medical thoracoscopy and either CT chest or TUS in the ability of detection of pleural masses there was no statistically significant difference (Table 1), also there was no statistically significant difference comparing them together (Table 2). This study showed that either medical thoracoscopy or TUS could be reliably used in detection of pleural masses. TUS still has some advantages over CT in detecting and diagnosing pleural masses: (1) practically, some patients with pleural masses and pleural effusions often had complaints of dyspnea and chronic cough; therefore, it was difficult or impossible for these patients to lie in bed for a thoracic CT examination and CT-guided needle biopsies (2) detecting the pleural masses in real-time and making needle biopsies simultaneously [10].

Comparing the ability to detect pleural nodules by CT chest or TUS versus medical thoracoscope, this study revealed that there was no statistically significant difference between TUS and medical thoracoscopy ($p = 0.570$) (Table 3), while medical thoracoscopy was superior over CT chest in detection of pleural nodules with statistically significant difference ($p = 0.000$) (Table 3), Also comparing the ability to detect pleural nodules by medical thoracoscopy, CT chest and TUS, this study revealed that there was statistically significant difference ($p = 0.001$) (Table 2), so either medical thoracoscopy or TUS could be reliably used in detection of pleural nodules.

Regarding the ability to detect pleural nodules by TUS (Table 4), there was statistically significant difference ($p = 0.025$) between malignant (group A) and non-malignant groups (group B) but there was no significant difference ($p = 1.00$) between primary (group A1) and secondary malignant cases (group A2). Regarding the ability of medical thoracoscopy in detection of pleural nodules (Table 4), there was statistically significant difference ($p = 0.009$) between group A and group B but no significant difference ($p = 0.405$) between group A1 and group A2, as direct visualization of the pleural surface during medical thoracoscopy helps to suspect a diagnosis and permits targeted biopsy from the abnormal pleural regions under direct vision.

This study showed that pleural nodules detected by Medical Thoracoscopy in 67.2% of cases and by TUS in 66.2% of cases were malignant as confirmed histopathologically (Table 4). These results coincide with Enas et al. [9] who stated that sonographic appearances of pleural nodules were mostly malignant, as confirmed histologically.

Regarding the ability of TUS to detect chest wall invasion (Table 5), there was statistically significant difference ($p = 0.015$) between malignant and non-malignant groups and there was no significant difference ($p = 0.511$) between primary malignant and secondary malignant cases, while CT chest couldn't detect any case of chest wall invasion.

Comparing the ability to detect the character of the collapsed lung (bulky or healthy collapse) by CT chest or TUS versus medical thoracoscopy, this study revealed that TUS was the best modality to detect bulky lung (Tables 6 and 7).

As TUS is a dynamic technique -and with the presence of adequate window – it could visualize beyond the visceral pleura and give an idea about the nature of the collapsed lung

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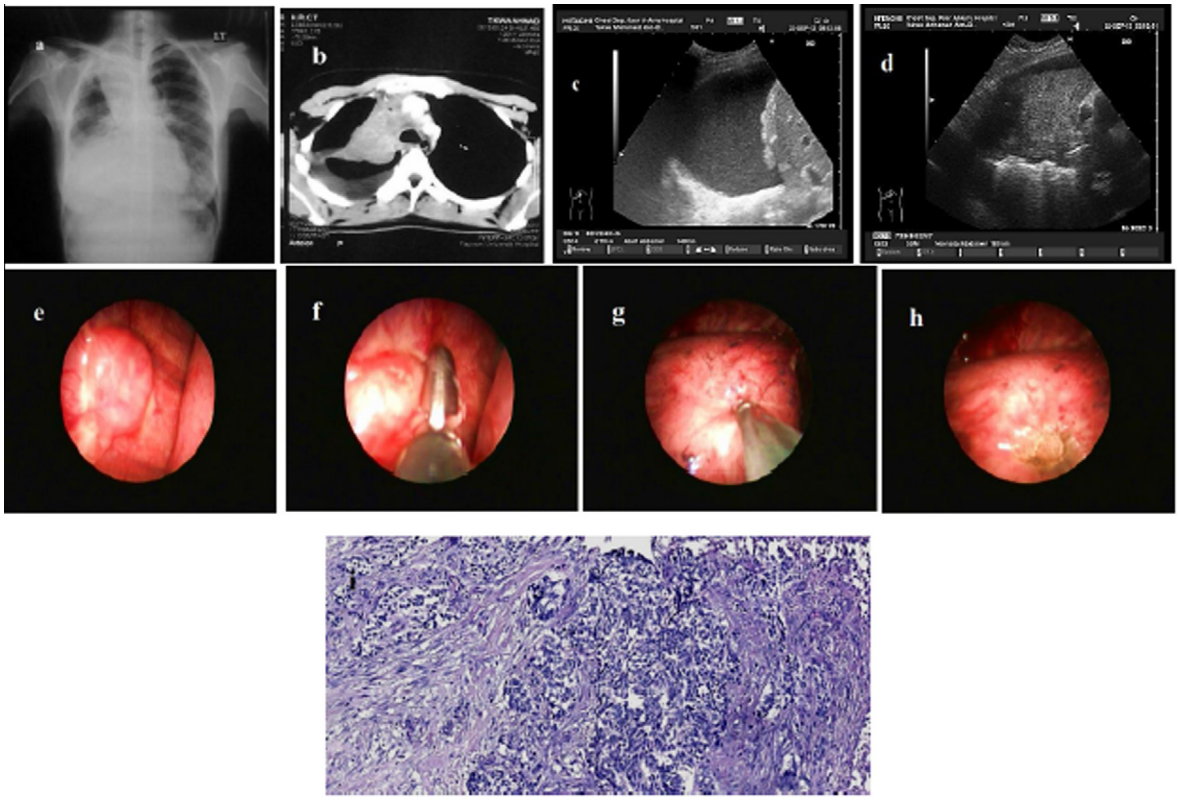

Figure 1 Female patient 30 years old, presented by gradual progressive dyspnea of 6 month duration. (a) CXR-PA showing moderate right sided pleural effusion with right paratracheal homogenous opacity, (b) CT chest mediastinal window showing right sided pleural effusion and bulky collapse of right upper lobe, (c)TUS showing complex non septated pleural effusion with nodule over diaphragmatic pleura, (d)TUS showing bulky right upper lobe with fluid bronchogram, (e) Medical Thoracoscopic picture showing nodule over costal pleura, (f) Medical Thoracoscopic picture showing biopsy from pleural nodule over costal pleura, (g) Medical Thoracoscopic picture showing lung biopsy from right upper lobe, (h) Medical Thoracoscopic picture showing cautery site post lung biopsy, (i) histopathological picture showing metastatic adenocarcinoma (H&E, 200×).

Table 5 Chest wall invasion as detected by TUS among the study patients.

	Malignant				Non malignant	Total	*p*-Value
	Primary	Secondary	Total	*p*-value			
Yes	7 (9.9%)	5 (7%)	12 (16.9%)	0.511	0 (0%)	12 (16.9%)	0.015*
No	17 (23.9%)	22 (31%)	39 (54.9%)		20 (28.2%)	59 (83.1%)	
Total	24 (33.8%)	27 (38%)	51 (71.8%)		20 (28.2%)	71 (100%)	

* $p < 0.05$.

either compression collapse under effusion or obstructive collapse due to central obstruction causing distal collapse (this could be detected by the presence of fluid bronchogram), Also medical thoracoscopy is a dynamic technique but it lacks the ability to detect beyond visceral pleura and lung surface.

This study revealed that TUS was the best modality to detect lung mass in secondary malignant group with statistically significant difference ($p = 0.004$) (Table 8), (Fig. 1).

The present study showed that TUS is superior over medical thoracoscopy in detection of lung masses and bulky lung, as TUS had the ability to visualize beyond visceral pleura – if there is available interface- and could detect vascularity of the lesion using Doppler wave and give an idea about its nature (benign, malignant) while medical thoracoscopy could only detect the visceral pleura and outer surface of the lung with provisional idea about the character of lung.

This advantage of TUS allowed us to take TUS guided biopsies from mass lesions in the lung in 3 cases and all these biopsies were diagnostic and guided us to take thoracoscopic lung biopsy in another 4 cases and all these biopsies were diagnostic.

There were no comparative studies assessing lung character by CT chest, TUS and medical thoracoscopy relative to each other.

Comparing the ability to detect pattern of pleural effusion (free or loculated) by CT chest, TUS and medical

Table 6 Comparison between either CT chest or TUS and medical thoracoscopy in detection character of collapsed lung among patients who underwent medical thoracoscopy.

		Thoracoscope character of collapsed lung			*p* value
		Bulky	Healthy	Total	
CT character of collapsed lung	Bulky	5 (8.2%)	0 (0%)	5 (8.2%)	0.379
	Healthy	3 (4.9%)	53 (86.9%)	56 (91.8%)	
	Total	8 (13.1%)	53 (86.9%)	61 (100%)	
TUS character of collapsed lung	Bulky	7 (11.5%)	7 (11.5%)	14 (23%)	0.158
	Healthy	1 (1.6%)	46 (75.4%)	47 (77%)	
	Total	8 (13.1%)	53 (86.9%)	61 (100%)	

Table 7 Comparison between medical thoracoscopy, CT chest and TUS in detection of character of collapsed lung among study patients who underwent medical thoracoscopy.

		Medical thoracoscopy	CT chest	TUS	*p* value
Character of collapsed lung	Bulky	8 (13.1%)	5 (8.2%)	14 (23%)	0.065
	Healthy	53 (86.9%)	56 (91.8%)	47 (77%)	
	Total	61 (100%)	61 (100%)	61 (100%)	

Table 8 The ability of CT & TUS to detect lung mass in malignant subgroups.

		Primary malignant	Secondary malignant	Total	*p*-Value
CT	Yes	0 (0%)	3 (5.8%)	3 (5.8%)	0.0923
	No	24 (47.1%)	24 (47.1%)	48 (94.2%)	
	Total	24 (47.1%)	27 (52.9%)	51 (100%)	
TUS	Yes	1 (2%)	13 (25.5%)	14 (27.5%)	0.0004*
	No	23 (45%)	14 (27.5%)	37 (72.5%)	
	Total	24 (47%)	27 (53%)	51 (100%)	

* $p < 0.05$.

Table 9 Comparison between either CT chest or TUS and medical thoracoscopy in detecting pattern of pleural effusion in patients who underwent medical thoracoscopy.

		Thoracoscope pattern			*p* value
		Free	Loculated	Total	
CT pattern	Free	36 (59%)	2 (3.3%)	38 (62.3%)	0.076
	Loculated	11 (18%)	12 (19.7%)	23 (37.7%)	
	Total	47 (77%)	14 (23%)	61 (100%)	
TUS pattern	Free	42 (68.9%)	3 (4.9%)	45 (73.8%)	0.619
	Loculated	5 (8.2%)	11 (18%)	16 (26.2%)	
	Total	47 (77.1%)	14 (22.9%)	61 (100%)	

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thoracoscopy, this study revealed that all techniques were close to each other, with no significant difference between all of them (Tables 9 and 10).

Adel et al. [11] stated that in TUS diagnosed 83.3% of free pleural effusion lesions, 60% of encysted pleural effusion lesions and diagnosed all empyema lesions, however it was less sensitive in detecting pleural thickening and pleural nodules or masses.

Also Sikora et al. [12] stated that transthoracic US serves as a more accurate imaging tool than chest radiography for the diagnosis of pleural effusions and allows discrimination of pleural effusions from other lung pathology that may appear similar on a chest radiograph. Furthermore, US can allow diagnosis of complicated pleural effusions, such as empyemas that may be associated with a higher risk of drainage.

Regarding the diagnostic yield of used modalities for diagnosis of pleural diseases in the present study it was found that the diagnostic yield of TUS was close to that of medical thoracoscopy but the difference between them didn't reach statistical significance ($p = 0.079$) (Table 11).

Regarding the complications of both procedures, TUS guided biopsies showed no complications compared to 7 (11.5%) patients who developed complications following medical thoracoscopic biopsies including 4 cases of surgical emphysema and 3 cases of wound infection and empyema.

The reported incidence of complications following medical thoracoscopic pleural biopsy was about 3% as stated by Hansen et al. [13] and 40.3% as stated by Metintas et al. [14].

According to a retrospective study by Blanc et al. [15] reported that out of 168 thoracoscopic procedures, 0.6% developed major complications that included death, severe sepsis, pulmonary embolism, hypercapnic coma while empyema was detected in (3.6%) of cases. On the other hand minor complications included residual pneumothorax (8.3%), subcutaneous emphysema (5.3%), fever (3.6%).

Mootha et al. [16] reported that out of 35 thoracoscopic procedures, 2 cases (5.2%) developed empyema with no other complications.

Also Prabhu and Narasimhan [17] found that out of 68 patients who underwent medical thoracoscopy, there were no major complications, only 4 patients had minor complications like subcutaneous emphysema (3 patients) and prolonged air leak (1 patient).

Abumossalam et al. [18] stated that complications reported in their study were few and of low risk. Five patients (7.25%) had thoracoscopic-related complications during this study. Two of them had empyema (2.89%); one had a residual pneumothorax (1.45%), one had subcutaneous emphysema (1.45%) and one had tumor implantation at the site of medical thoracoscopy tract (1.45%). These complications were properly managed. No bleeding or mortality was reported in their study and mortality rate was 0%.

The reported incidence of complications following closed pleural biopsy was about 10.9% as stated by Mungal [19] and 22.5% as stated by Metintas et al. [14] while the reported incidence of complications following image guided Tru-cut pleural biopsy was about 3% (Benamore et al. [7]).

Enas et al. [9] stated 10% of patients underwent TUS biopsies developed complications and 10% of patients underwent medical thoracoscope developed complications in the form of empyema and wound infections.

TUS guided biopsies had sensitivity of 77.78% and diagnostic accuracy of 81.25% (Table 12); while medical

Table 12 The sensitivity and diagnostic accuracy of TUS guided biopsies and medical thoracoscopic biopsies.

	TUS biopsies ($n = 32$)	Medical thoracoscopic biopsies ($n = 61$)
True positive	21 (65.6%)	47 (77.1%)
False negative	6 (18.8%)	3 (4.9%)
True negative (pleural fibrosis)	5 (15.6%)	11 (18%)

Sensitivity of TUS guided biopsies (%) = 77.78%.
Diagnostic accuracy of TUS guided biopsies (%) = 81.25%.
Sensitivity of Medical Thoracoscopic biopsies (%) = 94%.
Diagnostic accuracy of Medical Thoracoscopic biopsies (%) = 95.08%.

Table 10 Comparison between medical thoracoscopy, CT chest and TUS in detecting pattern of pleural effusion in patients who underwent medical thoracoscopy.

		Medical thoracoscopy	CT chest	TUS	p value
Pattern of pleural effusion	Free	47 (77%)	38 (62.3%)	45 (73.8%)	0.169
	Loculated	14 (23%)	23 (37.7%)	16 (26.2%)	
	Total	61 (100%)	61 (100%)	61 (100%)	

Table 11 Comparison between diagnostic yield of TUS and medical thoracoscopy results in 22 cases underwent both procedures.

		Thoracoscope results			p value
		No	Yes	Total	
TUS results	No	0 (0%)	5 (22.8%)	5 (22.8%)	0.079
	Yes	1 (4.5%)	16 (72.7%)	17 (77.2%)	
	Total	1 (4.5%)	21 (95.5%)	22 (100%)	

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thoracoscopic biopsies had a sensitivity of 94% and a diagnostic accuracy of 95.08% (Table 12).

The diagnostic yield of thoracoscopy is high; it is reported to be above 90% in the majority of studies and sensitivity between 90 and 95% Boutin et al. [20] diagnostic yield of medical thoracoscopy was 97%, Blanc et al. [15] diagnostic yield of medical thoracoscopy was 93.3%.

Chang et al. [21] previously found the diagnostic yield of US guided Tru-cut pleural biopsy to be as high as 87% for all pleural pathologies.

Diacon et al. [22] reported an 86% sensitivity and a 100% specificity with transthoracic ultrasonography-guided biopsy when they used a 14-gauge cutting needle for pleura-based lesions 20 mm or greater in diameter.

Koegelenberg et al. [23] the respective yield for both US-assisted Abrams or Tru-cut needle types for pleural malignancies was comparable and relatively high being diagnostic in approximately 83.3% of cases.

Enas et al. [9] stated sensitivity of medical thoracoscopy was 100% and a sensitivity of TUS guided biopsies were 90%.

In the present study 7 cases out of 32 cases of US guided biopsy underwent Abrams guided biopsies however none of them were diagnosed by this modality, their histopathological examination showed minimal representative pleural tissue and skeletal muscle, this may be related to the technique of the procedure as site of biopsy is directed by US while at time of biopsy taking it's blind and may hinge on any tissue through its path so that it may not submit adequate pleural tissue sufficient for diagnosis.

On the other hand, Koegelenberg et al. [23] in a prospective randomized study found that US-assisted Abrams needle biopsy specimens were more likely to contain pleural tissue than specimens obtained by means of US-assisted Tru-cut biopsies (91.0% versus 78.7%, $p = 0.015$). Furthermore, Abrams needle biopsies had a significantly superior yield for pleural TB compared to Tru-cut needle biopsies (81.8% versus 65.2%, $p = 0.022$), but not compared with previously reported figures for blind Abrams needle biopsies.

Ahmed et al. [24] stated that, out of 20 patients who underwent image-assisted Abram needle pleural biopsy, 15 patients were diagnosed; 7 patients diagnosed with benign disease and 8 patients diagnosed with malignant disease, with an overall diagnostic sensitivity of 75%. Also, out of 20 patients who underwent medical thoracoscopy, 17 patients were diagnosed; 8 patients diagnosed with a benign disease and 9 patients diagnosed with malignant disease, with an overall diagnostic sensitivity of 85%. The increased sensitivity of the image-assisted Abram needle biopsy technique used in this study had been attributed to its use in a pleural thickening of 1 cm or more, and by using a tangential approach, to achieve adequate diagnostic samples, in patients with thin pleural thickening less than 1 cm.

Conclusion and recommendations: TUS examination before medical thoracoscopy will allow proper selection of patients, reduce incidence of complications, guide for best site of entry and raise diagnostic yield of medical thoracoscopy. Both TUS guided pleural biopsy and medical thoracoscopic pleural biopsy are available to do biopsies of different pleural lesions and each of which had its advantages and disadvantages. The proper selection of the patients for each modality will result in raising the diagnostic yield of both modalities.

Use of TUS in detection of the best site for entrance of medial thoracoscope in cases of absence of pleural effusion (selection of site of best lung sliding to avoid visceral and parietal pleural adhesions).

Conflict of interest

There is no conflict of interest.

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